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ADDRESSING SCIENCE NEEDS IN THE LAKE TAHOE BASIN

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Angora Burn Area Monitoring Plan
Lake Tahoe Basin, California

Submitted in response to a request from
Lauri Kemper
Management Agency Coordination Committee Co-chair

July 3, 2007

Desert Research Institute
USGS science for a changing world
UC DAVIS TAHOE ENVIRONMENTAL RESEARCH CENTER

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I. Introduction

The Angora Ridge fire burned approximately 3,100 acres of land area in the southwest portion of the Lake Tahoe Basin, California. Undeveloped montane, mixed conifer forest habitat was the dominant land type within the burn area, but significant areas of urban development were also affected.

Several short-term assessments are underway to better characterize the extent and severity of the fire affects. These assessments also will determine actions needed to remediate the direct fire effects, and determine the most immediate efforts needed to reduce further adverse impacts.

The Angora Fire Recovery Plan now under development makes it clear that all agency efforts are focused on recovery of the burn area, both the natural and human environments. Recovery efforts are expected to occur over three phases covering a 10-year period: immediate term (first 12-16 weeks, post-fire), near term (first year, post-fire), and long term (post-fire, years 2-10). Thus, monitoring beyond the short-term assessments is required to address two major questions:

<u>What is the full extent of environmental impacts caused by the fire?</u> While the short-term assessments will characterize many of the most immediate impacts of the fire, we know that significant impacts such as soil erosion, degradation of water quality, and alteration of stream geomorphology will continue to occur. In fact, the full affects of many of these impacts will be driven by subsequent precipitation events. Further, impacts to terrestrial and aquatic biota and their habitats will require more in-depth study to understand the full extent of these impacts.

<u>What are the effects of post-fire remediation and rehabilitation efforts?</u> Numerous and extensive remediation and rehabilitation efforts are expected to occur over the next several years. Careful monitoring is needed to document the effects and effectiveness of these actions.

This monitoring plan presents a comprehensive suite of efforts necessary to answer these questions. The plan was prepared by an interdisciplinary team of agency technical staff and members of the science community. All participants provided expertise in one or more topic areas covered in this plan. The individual participants were:

Alan Heyvaert (DRI), Shane Romsos (TRPA), Myrnie Mayville (USBR), John Munn (Calfire), Bob Coats (UCD), John Reuter (UCD), Kim Gorman (LRWQCB), Wally Miller (UNR), Michael Hogan (IERS), Nathan Shasha (CSPR), Virgina Mahacek (Valley & Mountain Consulting), Scott Carroll (CTC), Raph Townsend (UCD), Russ Wigart (El Dorado Co.), Jason Holley (CDFG), Peter Stine (USFS/PSW), Tim Rowe (USGS), and Zach Hymanson (TSC).

II. Monitoring Plan Summary

This plan describes the monitoring efforts recommended for five topic areas: 1) air quality, 2) upland soils and erosion control effectiveness, 3) stream geomorphology, 4) water quality, and 5) biological resources. Specific questions were determined for each topic area, and the monitoring efforts were developed to answer these questions. Generally, the monitoring efforts rely on a combination of existing (before fire) data and analyses, new field and laboratory efforts to collect data during (in the case of air quality and water quality) or after the fire, and new analyses to answer the specific questions. In some cases (e.g., air quality and biological resources) reference conditions are also determined to better assess fire effects.

In all cases the recommended monitoring efforts are proposed for completion by academic scientists and/or technical consultants with agency oversight. We assume this approach is the most expedient way to initiate the monitoring activities. This approach also allows the funding agencies greater flexibility to adjust monitoring efforts as new information warrants. Cost estimates were prepared based on this assumption. Efforts to initiate monitoring activities can begin as soon as the necessary funding agreements are in place. In several cases, some time (~30-45 days) will be required to acquire the necessary resources and establish the required monitoring stations and infrastructure.

The plan assumes that essential data and results from initial assessments and more comprehensive GIS work will be made available to this effort at no additional cost. Further, it is assumed that data and information essential to all monitoring efforts and the restoration effort (e.g., detailed meteorological data), will be made available to this effort at no additional cost.

This plan assumes the recommended monitoring will continue for five years (during recovery phases 2 and 3), followed by a comprehensive assessment (in year 6) to assess recovery efforts and re-scope the recommended monitoring efforts. Descriptions of the monitoring recommended for each topic area are provided in the sections below. These descriptions are abbreviated due to the time (~2 days) provided for development of this plan. More complete details about the sampling design and methodologies, quality assurance procedures, etc. will be provided once the team leaders have received authorization to undertake the recommended monitoring. A summary of costs by topic area is presented in the table below. These costs should be considered estimates, given the abbreviated timeline under which this plan was developed.

Topic Area	Team Leader	Existing infrastruc. & resources	Existing funding	One-time start-up costs	Year 1* costs	Year 2 Costs	Year 3 Costs	Year 4 Costs	Year 5 Costs	Year 6 Costs
Air Quality	Tom Cahill (UCD) & John Reuter (UCD)	Several air sampling stations and some analyses	$8,000 (SNPLMA); $20,000 (UCD/LTIMP)	$8,000	$48,172	--	--	--	--	--
Upland Soils	Wally Miller (UNR) & Michael Hogan (IERS)		--	$13,600	631,000	$650,000	$670,000	$690,000	$711,000	$50,000
Stream Geomorph ology	Virginia Mahacek (V&M Consulting)		--	$47,000	$76,000	$79,000	$80,000 (funding for event sampling that could happen in any years)	$81,000	$84,000	$30,000
Water Quality	Alan Heyvaert (DRI), John Reuter (UCD), and Tim Rowe (USGS)	Sampling stations on Angora Ck. and the UTR; flow data from CSPR	$30,000 (LTIMP funding)	$232,000	$777,000	$800,000	$824,000	$849,000	$875,000	$65,000
Biological Resources	Peter Stine (PSW)		--	$43,000	$392,000	$404,000	$416,000	$428,000	$441,000	$60,000
Project Manager	TBD		--	--	$150,000	$155,000	$160,000	$165,000	$170,000	$175,000
Total Costs				**$343,600**	**$2,074,172**	**$2,088,000**	**$2,150,000**	**$2,213,000**	**$2,281,000**	**$380,000**

*Annual costs after year one have been adjusted for inflation, assuming a 3% inflation rate.

III. Proposed Working Structure

The work proposed in this monitoring plan would be carried out as a fully integrated set of activities. This will require active an ongoing communication and coordination. It is assumed that an existing federal and an existing state program manager will be jointly assigned to administer the program of work described here. The budget detailed in the table above includes funding for a full-time project manager, who will be essential to ensuring the ongoing success of this monitoring program. Working with the technical teams, this individual will be responsible for:

- Day-to-day coordination of all monitoring efforts and work to ensure maximum efficiency and effectiveness.
- Ongoing communications with the program managers, executive representatives, and the public
- Developing an integrated annual report of all monitoring activities for agency executives, elected officials and their staff, and the general public. This annual report will be based on the more detailed individual technical reports produced specific to each topic area.
- Administering any independent peer reviews of technical reports.
- Overseeing the sixth-year comprehensive analysis and monitoring program review.

Each topic area will have a technical team and team leader (or principal investigator). The project manager and team leaders will form the technical oversight team who will oversee implementation of all monitoring activities.

IV. Air Quality Monitoring

Atmospheric pollutants that contribute to overall air quality at Lake Tahoe derive from both natural and anthropogenic sources. Wildfires, volatile organic compound emission from trees and wind blown dust from natural landscapes all are examples of natural phenomena. In contrast, automotive and industrial pollutants, prescribed fire smoke, and human caused wildfire smoke all derive from anthropogenic sources. The Angora fire is considered a human-cause wildfire that included surface burning, passive crowning, and active crowning.

Degradation of air quality poses two distinct environmental threats to the Lake Tahoe basin: 1) reductions in air visibility, and 2) decline in Lake water quality. Both of these factors are strongly impacted by fires especially if they are within the basin.[1]

[1] For further information see Cahill, T.A. and S. Cliff. Air Quality. In: Murphy, D.D. and C.M. Knopp (eds.) 2000. Lake Tahoe Watershed Assessment: Volume I. USDA, Forest Service,

The Angora fire offers us opportunities to gain valuable information on four fronts:

1. A full evaluation of the effect of the Angora fire on basin visibility, with implications to the use of prescribed fire within the basin and the potential effects of subsequent wildfires.
2. A full evaluation of the effect of the Angora fire on lake clarity, with implications to the use of prescribed fire within the basin and the potential effects of subsequent wildfires.
3. A study of the presence of fugitive ash and dust from burned areas, with primary implications to declines in lake clarity.
4. Analyses of ash at the site for phosphorus and fine soils.

Given the event-driven nature of this work (i.e., impacts must be assessed during the event), sample collection was initiated on June 25, 2007. A recently awarded SNPLMA grant (EPA Region IX sponsor), while focusing on studies of fine particles entering the lake for lake clarity effects, does include a small ($8,000) addition to study in-basin fires. We propose to use these funds for the analysis of Angora fire air quality impacts, but the available funding will not cover the entire costs.

We are attempting to reestablish sampling at the abandoned ARB site at Sandy way, South Lake Tahoe, and the IMPROVE site at Bliss State park. Such sampling would have been invaluable for the Angora fire.

Here we briefly describe the efforts undertaken during the fire event and recent post-fire work. We also describe the additional work and funding necessary to complete a full assessment.

Measurements taken during the fire

An eight-stage DRUM sampler, with time resolution as short as ½ hr, was set up in April on the roof of the new Tahoe Center for Environmental Sciences (TCES) building. This unit will gather valuable data on any smoke that travels as far as Incline Village.

As part of an ongoing NOAA study, Dr. Steve Cliff was operating at the same time an operationally identical 8 DRUM sampler at the snow lab on Donner Summit. This will give invaluable data on the regional aerosol background and transport from the western slopes of the Sierra Nevada to Lake Tahoe during the fire.

The UCD, Tahoe Environmental Research Center team responded immediately and set up Minivols and deposition buckets (albeit a limited number) around the lake, starting at about 1 PM on June 25, 2007. They used the 1um Teflon filters

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washed with HF HNO3 and HCl. Regretfully, there was no opportunity to pre-weigh the filters, so the analyses will require elemental and chemical analyses to estimate mass. Chemical analyses are being conducted on these samples by UC Davis and Stanford University collaborators. Minivols were set up side by side with deposition buckets at the following locations.

1. Roof of the TCES building: Minivol only (existing 8 DRUM operational)
2. Cave Rock area: Minivol only
3. South Lake Tahoe: Minivol + bucket
4. Tahoe City near Lake Forest: Minivol only
5. Wallace pier (near Ward Creek): Minivol + bucket
6. Emerald bay area (Bliss State Park): Minivol only
7. Buoy #1 (north end of the lake): Minivol + bucket
8. Buoy #2 (north end of the lake): Minivol + bucket

Two sets of samples were taken, on June 25 – 26 and June 26 – 27. The plan is also to sample after the fire as a backward baseline.

Resources needed to fully analyze Angora fire impacts:

Task 1: Analysis of Air Visibility

Samples from existing and new sampling sites will be analyzed to assess and quantify the Angora fire impacts to basin air visibility.

Costs: Covered in the EPA grant

Task 2: Analysis of Air Quality Impacts on Lake Clarity

Smoke and ash emitted from forest fires is known to contain high levels of nitrogen, phosphorus and particulate matter. Deposition of this material directly to the surface of Lake Tahoe, from the atmosphere, has the potential to decrease water clarity. Immediate impacts would be expected in the vicinity of the South Shore where levels of smoke and ash in the air were the greatest. The immediate affects would diminish with distance from the fire as levels of smoke and ash declined. Under typical circumstances, these immediate affects should last for a period of not more than one month. Since nutrients and particles can have a long residence time in Lake Tahoe (anywhere from 1-20 years depending on the constituent) there could also be a long-term consequence from the increased pollutant loading.

In the days following the fire, the UC Davis-Tahoe Environmental Research Center (TERC) conducted lake monitoring to address the question of immediate affects. Two surveys for water quality were made within the first week. One focused on the South Shore region and the other included sites around the entire lake. Data was collected for clarity, light transmission, algal biomass, nutrient chemistry and temperature. A third whole-lake survey is planned at three weeks post-fire. Additionally, smoke and ash collected from the air was used to conduct a series of algal growth experiments in the laboratory to evaluate possible affects of this material on algal growth rate.

UC Davis has operated two deep-water lake monitoring stations for many decades – located in the northern portion of the basin. Continued sampling from these established locations will allow for an evaluation of the long-term affects.

Work on the immediate impacts is nearly complete with an estimated cost of approximately $25,000. This cost has been covered by programmatic support to the TERC by UC Davis and the Lake Tahoe Interagency Monitoring Program.

We had not planned to analyze the samples from Donner Summit prior to the installation of an additional buoy-based DRUM sampler, so no funds were budgeted for this task. Yet it is now vital to be able to evaluate transport into the basin since other fires were also burning at the same time.

We had not planned to analyze the samples from TCES building for elemental values by S-XRF prior to the installation of the DRUM sampler on the buoy, so no funds were budgeted for this task.

Estimated costs for this additional sample analysis (for six weeks of sampling centered around the fire: $6,400

We had always anticipated analysis of samples from both DRUM samplers for mass and optics, and these are covered in the EPA grant.

Task 3: Monitoring of wind blown ash and dust from the burned areas

We propose to locate a three-DRUM at the Tahoe High School, at the very edge of the burned area, and an eight-DRUM at the ARB site, Sandy Way, in South Lake Tahoe. The sandy way site will tie these data into the long term TRPA and ARB record for South Lake Tahoe. We propose to operate for these samplers for six months until snow falls. Operation after the snow falls until Spring, 2008, is covered by the EPA grant as part of the evaluation of road sanding and salting on lake clarity.

<u>Estimated Costs</u>:

<u>Tahoe High School</u>

Set up, operation, mass and optical analysis: $6,000
S-XRF data (essential for the phosphorus content): $14,400.

<u>Sandy Way</u> (4 coarsest stages only to see blowing ash)

Set up, operation, mass and optical analysis $6,000
S-XRF data (essential for the phosphorus content) $9,600.

Task 4 Analysis of ash and fine soil form the wildfire site

This is a major opportunity to compare the residual ash from wildfires and prescribed burns. From the Oregon Biscuit fire (2002) it appears that intense wildfires liberate phosphorus in ash that is not seen in prescribed fires.

Costs:

Partially covered in the EPA grant, but additional funding is needed because of the size and intensity of the fire: $2,400.

Cost summary: Total Cost required: $56,672 ($44,800 direct costs + $11,872 (26.5%) indirect costs)

Team Leaders: Thomas A. Cahill and Geoff Schladow (UCD/TERC)

Start and End Dates: Summer 2007 to December 31, 2007

Deliverables: Final report, addressing the four tasks above Database of field and laboratory data, data analyses and interpretive reports.

Timing of Deliverable: December 31, 2007

Start date: June 25, 2007

Deliverable: Final report, addressing the four tasks above

Report date: December 31, 2007

V. Upland Soils and Erosion Control Effectiveness

Upland Soils

The integrity and stability of upland soils have a direct influence watershed function, discharge water quality, and vegetation community dynamics. Subtopics include the physical, chemical, and biological components and their interaction. Monitoring goals would address the following:

- To assist in characterizing the link between impacted upland watershed soils relative to nutrient and sediment discharge, interception by intervening riparian and meadow zones, and tributary discharge. This will include linking soils and water quality monitoring data.
- To assess the short, intermediate, and long-term impact trends on soil infiltrability and runoff, fertility and nutrient cycling, vegetation recovery, nutrient status, and discharge water quality. This will include linking the soils data to vegetation monitoring data.
- To evaluate the effectiveness of impact mitigation strategies.
    a. Basic Questions
        i. What are the initial effects of the wildfire on existing ecosystem and environmental parameters?
        ii. What are the long-term effects and how do they change over time?

  iii. How effective are restoration and rehabilitation activities at mitigating adverse impacts and can new and more effective techniques be developed?

b. Specific Questions of Concern: How did the wildfire influence nutrient and sediment discharge loads relative to the following factors?
   i. Urban vs. forested vs. meadow
   ii. Slope gradient
   iii. Fire intensity
   iv. Pre-fire biomass treatment
   v. Pre and post fire vegetation communities and density
   vi. Fire retardant application
   vii. Restoration/Rehabilitation treatment

c. Measurement Parameters
   i. Soil Physical Properties – Infiltration, runoff, soil water repellency, texture, bulk density, estimated water retention
   ii. Soil Chemical Properties – Salinity and pH, nutrient status and flux (cations/anions, selected totals), organic matter, soil solution
   iii. Water quality of runoff, precipitation, soil solution, snowmelt
   iv. Vegetation – Pre-existing, remaining, recovery
   v. Precipitation – Intensity, duration, form

d. Measurement Frequency
   i. Annual Assessment
   ii. Seasonal Assessment
   iii. Event Based Assessment

e. Monitoring Design

- There are three areas of typical land use status: urban, forested, and meadow. Each general location is characterized by one or more slope gradients. The urban sites are located on low, medium, and high slopes. Forested (non-urban) areas are typified by medium and high slopes. And meadow wetlands are located on low slopes. This yields a general matrix of six characteristic monitoring locations.
- In addition, there are five reaches along Angora Creek (a principle tributary to the Upper Truckee River that are subject to geomorphic

characterization (see stream geomorphology section below). These will serve as five additional monitoring locations.

- Each monitoring location will be characterized by one of four general burn intensities (zero, low, medium, high), three biomass treatments (none, mechanical, and hand removal), and two fire retardant treatments (none, applied). Not all scenarios will apply at each location.
- An unknown number of areas will be subjected to a variety of restoration/rehabilitation activities.
- Each monitoring location will consist of transects with five measurement stations along each transect, where soil physical, soil chemical, vegetation community, and precipitation (rain and snow) will be assessed.
- There are a total of eleven priority locations; six slope by land use interactions, and five tributary geomorphology assessments.
- An unknown number of sub-location treatments may exist that consist of variable burn intensities, biomass, retardant, and restoration/rehabilitation treatments.

Erosion Control Effectiveness

The Angora fire created conditions that will likely require substantive erosion control measures to avoid or reduce future potential impacts. Monitoring is necessary to determine the effectiveness of fire site recovery efforts. This monitoring is intended to address the following question:

How well does a range of recovery treatment actually work to a) reduce sediment and b) lead to recovery of soil and vegetation function?

<u>Approach</u>:

This monitoring looks at function in the soil and vegetation immediately following the Angora fire and in subsequent recovery seasons.

We are currently monitoring twelve sites for a Caltrans project. Within these sites, we have over thirty treatment types and area gathering the following data:

- Total and vegetative cover, vegetation identified to genus or species, 90% confidence level
- Soil moisture
- Soil density
- Soil strength (using a shear vane measurement system)
- Soil nutrients (all micro and macro nutrients plus TKN and organic matter)
- Total solar exposure

- Full site physical and geographical assessment with map, photopoints and transects shown
- Data analysis and reporting

This monitoring provides the following information:

- Type and species of nutrients in the burned area soils compared to unburned areas (Organic matter, N, P, S, micronutrients, pH, etc.)
- Change in soil strength following fire
- Change in soil density
- Difference in soil moisture content in burned areas from unburned areas
- Amount and type of soil cover
    - Mulch cover will infer resistance to surface erosion
    - Plant cover will suggest intensity of burn
- Amount of hydrophobicity before and after burn (using reference site information)
- Amount of infiltration for a given rainstorm (we will not wait for a 'natural' event and thus won't confound data with the myriad of variables that exist in a natural event)
- Amount of runoff and constituents in that runoff, including N, P, S, as well as particle size distribution, especially focusing on fine particles.

This analysis will allow us to understand how well specific post fire erosion control and site restoration treatments are working. During multi year monitoring, we will be able to determine successional patterns and changes in overall cover, nutrient status, invasive species, soil moisture trends and a number of other ecological parameters that will be critical in understanding fire effects on the ecosystem.

This data also will allow us to further calibrate and fine tune the LSPC model – current the water quality/watershed model being used to support the Tahoe TMDL Program. Our group applied our existing data which was derived in exactly this manner, to populate the LSPC model for the Lake Tahoe TMDL efforts. Without this type of treatment-based approach, other monitoring efforts are unlikely to offer the resolution or precision to understand treatment trends. Linked with other monitoring efforts (upland soils, water quality, etc.) this treatment based approach will present a more complete picture of general fire effects as well as overall recovery treatment effects.

Cost Summary:

Upland Soils:

Monitoring costs per baseline location are estimated at $15,000/location. For eleven baseline locations the cost per year would be approximately $165,000.

Accounting for ten additional locations capable of characterizing key interactions among sub-treatment parameters, an additional cost of $150,000/yr would be required. Data management, analysis, and reporting are estimated at $50,000/yr.

Total cost for the upland soil monitoring would be $459,900/yr. ($365,000/yr. direct costs + $94,900/yr. (26%) indirect costs)

Erosion Control Effectiveness:

For direct measurement of infiltration, runoff, runoff constituents and particle size in runoff, estimates are $3470 per site/treatment type. X 10 sites = $34,700/yr.

For treatment/restoration effectiveness, which is a critical and poorly understood fire related practice, we recommend the suite of measurements at 30 sites (5 reference sites) for $150,000/yr.

Total cost for erosion control effectiveness monitoring would by $184,700/yr.

Team Leaders:
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Michael Hogan (IERS); mhogan@ierstahoe.com; (530)

Mark Grismer (UCD); megrismer@ucdavis.edu

Start and End Dates: Summer 2007 through 2012 (5 years), with needs re-assessment

Products and Deliverables: Database of field and laboratory data, data analyses and interpretive reports.

Timing of Deliverables: Annually

VI. Stream Geomorphology

The stream geomorphology monitoring of post-fire conditions following the Angora Fire will address the potential adjustments of the physical channel system to changes in streamflow and sediment loads within the watershed. The focus of the monitoring will be on those portions of the burn area watersheds that presently have defined channel systems and do not have existing in-channel lakes or ponds downstream of the burn area that will moderate the flow and sediment changes (i.e., main stem Angora Creek and the unnamed 'Seneca Pond' tributaries).

The monitoring approach is to conduct baseline and response monitoring over time of the stream channel within the Angora Creek watershed, including areas in and downstream of the burn area. Little channel length or watershed area is upstream of the burn area, precluding upstream/downstream comparisons.

Questions

The primary geomorphic question is to determine the type, location, and magnitude of fire effects on channel condition in the tributaries and main stem of Angora Creek. Specific geomorphic questions include:

- Will the channel be able to remain stable while conveying the changes in sediment and hydrology?
- Will the channel pattern and planform change in both natural and/or restored reaches? Will there be avulsions and/or additional channels generated? Will headwater channel initiation or extension occur?
- Will the channel profile be modified by aggradation and degradation, and if so, where?
- Will bank stability decrease and bank erosion increase, and if so, where?
- How will changes in channel morphology, bed forms, and substrate affect physical habitat?
- Will overbank deposition of sediment be altered by avulsions/channel aggradation, etc.?

Some questions relating to channel geomorphic process may be jointly monitored as part of other topics, for example:

- How will changes in peak streamflow and peak stage (depth) of water within the channel affect channel hydraulics?
- How will suspended sediment load changes interact with channel hydraulics to produce geomorphic response?
- How will riparian/streambank vegetation type and conditions, as related to pre-burn patterns and burn intensity distribution, affect bank stability?

Some questions relating to channel geomorphic response to the fire require input regarding driving forces that can be addressed by geographically stratified sampling, such as:

- How does variation in geology/geomorphic surfaces/soils and slope affect channel response?
- How does contributing area/proportion burned and severity of burn affect channel response?
- How will post-fire treatments modify flow and sediment loads to the channels, and channel response?
- Are there differences in urban versus non-urban sub-watershed effects?

In addition to data needs specifically for the above questions, data regarding the independent driving forces linked to site-specific weather will be needed for over the entire monitoring period.

What do we know? What are we already doing?

There is no existing long profile throughout the Angora Creek watershed, and no comprehensive geomorphic inventory of channel conditions or trends. However, there are discontinuous surveys with monumented cross sections in three restoration project sub-reaches (two are downstream of the burn area, one is within the fire perimeter).

- 1.5 km golf course sub-reach (~9 monumented cross sections last surveyed since 2000) (CSPR).
- 1.2 km sewer line sub-reach (>10 monumented cross sections, 10 of which were last surveyed in 2006) (CSPR).
- Approximately 1.5 km Angora SEZ sub-reach some monumented cross sections, of which some are part of the 2006 as-built survey)(by Graham Matthews Associates for EDOT).

Recently, a qualitative survey of channel stability was conducted upstream of Lake Tahoe Boulevard as part of the Angora 3 Erosion Control Project, including 3 surveyed cross-sections (it is not sure if these are tied to a long profile or monumented) (by ENTRIX for EDOT, 2005).

What work is needed

<u>Where:</u> Stream geomorphic monitoring will be concentrated within the Angora Creek mainstem and Seneca Pond tributaries (Figure 1). No specific stream geomorphic studies are proposed on the Sawmill Pond, Osgood Swamp tributaries, or the non-channelized area draining northeast of Gardner Mountain. A tiered approach will combine comprehensive, but less-detailed surveys along the ‘entire’ reach with focused, detailed surveys in six sub-reaches (Figure 1).

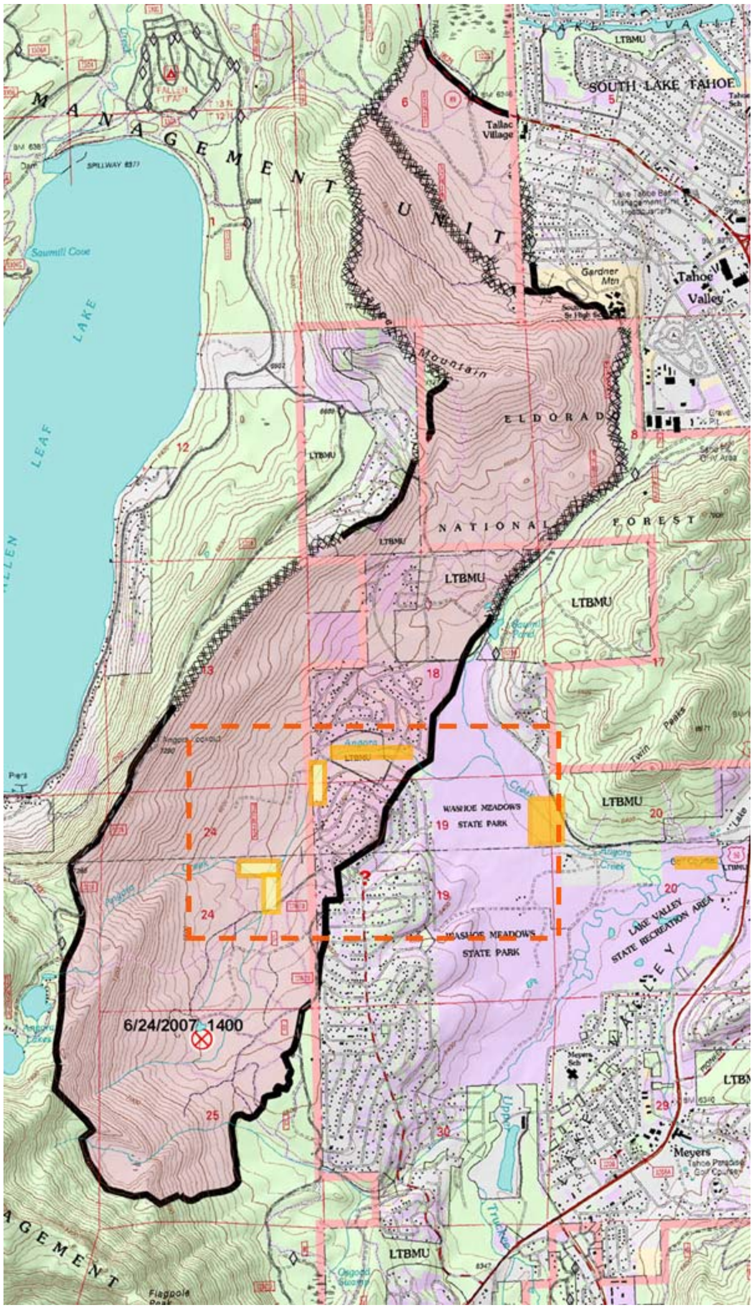

Figure 1: Angora Fire Burn Area and Proposed Geomorphic Monitoring Locations

The ‘entire’ study reach working definition would extend from the downstream end of the CSP sewer-reach restoration project to at least 500 m upstream of the Seneca Pond tributaries confluence.

The six selected sub-reaches include three restoration project reaches that have already had prior geomorphic studies, and three new reaches. The resulting combination of burn conditions, slope and land use categories include:

Four in the burn area

- Two forested channel types (high gradient and moderate gradient);
- One low gradient mixed urban/forested;
- One moderate gradient urban (reconstructed channel)

Two downstream of burn area

- Two in low gradient meadows (reconstructed/restored channels)

<u>What:</u> Critical measured data will be repeat topographic survey of the channel and floodplain and bed sediment sampling (one sample each in the six focused areas only). These data will document potential changes in channel dimension, position, shape, and bed materials.

Additional measured data will be stage and peak stage measurements in focused survey areas to supplement the continuous hydrology monitoring anticipated as part of upland and water quality monitoring.

The remaining data will be qualitative observations along the entire reach of physical habitat, bed and bank sediment characteristics, burn severity along channel banks, bank vegetation, overbank (floodplain) processes, and other features (e.g., LWD, beaver dams, etc.)

<u>How:</u> A total station (x,y,z) topographic survey will be made for each repeat survey, tied to bench marks and datum that can be used in GIS to overlay with other pre-fire and post-fire data sets.

The long profile will capture the thalweg (deepest part of the channel) at least every 50 feet and at significant breaks in the bed slope; top and toe of bank will also be surveyed approximately every 500 feet and/or at significant changes in bank heights, side slope types, and/or drainage confluences.

The cross sections will span the floodplain and/or lowest terrace surface within which the channel occurs. In the three existing restoration project focus areas, existing monumented cross-sections will be re-occupied. In the three new focus areas, new cross-sections will be established, monumented, and re-surveyed. Detailed cross-sections will be spaced approximately every 50 to 100 feet along the profile, at representative locations to be coordinated with other soils/vegetation transect surveys. Topographic points will be surveyed along each cross-section at all significant breaks in slope or at least every 20 feet

When: The baseline post-fire survey should to be conducted immediately (as soon as feasible) during the summer of 2007 (Year 0). Hopefully the baseline survey would be completed prior to any post-fire storm runoff events.

Repeat geomorphic surveys would be conducted after peak runoff season ('summer') in Years 1, 3, and 5.

Event-driven repeat geomorphic surveys would be conducted as soon as feasible following the threshold event(s) of high intensity rainfall/runoff and/or high magnitude runoff, preliminarily established as:

In years 1-5

- A rainfall event higher than 1 inch/hour, OR
- A runoff event greater than 5-year magnitude.

Data shared with/from other monitoring plan components

The stream geomorphology monitoring plan and data analysis will require starting base GIS layers of available pre-fire background conditions and fire assessment information.

The stream geomorphology monitoring site selection, parameter monitoring, and possibly the event scheduling would likely be coordinated with the upland soil/vegetation and water quality topics.

The stream geomorphology monitoring analysis will require input from other topics' data collection programs, including runoff and sediment loads information from upland areas and/or channels, soil characteristics, and vegetation conditions along stream channels.

The stream geomorphology monitoring data will provide physical habitat inventory information along the entire reach of Angora Creek for all scheduled years and events for which repeat surveys are conducted.

Data gathered for the post-fire monitoring along these stream channels will provide information that can be integrated into existing post-restoration project evaluations and planned geomorphic research to refine predictive models of bank stability and channel process (BSTEM and CONCEPTS) being applied within the Lake Tahoe Basin for ongoing TMDL process.

What will it cost?

The cost estimate for geomorphic surveys (Table 1) assumes that contracted (private) surveyors/geomorphologists would be used, although it is possible that qualified agency staff may assist with or implement portions of the data collection and analysis (at least in subsequent years). The cost estimate makes a simple inflation assumption of 3%/year. Initial surveys in year 0 include one-time costs to tie into benchmarks, select cross sections and photo-points, and to install cross-section monuments.

Table 1: Angora Fire Stream Geomorphology Monitoring Cost Estimate

	Year 1	Year 2	*Year 3	Year 4	Year 5	**Events (1)	Total	
Long Profile Surveys	$45k	$26K	--	$27K	$27K	$27k	$152k	
***Detailed Cross Section Surveys	$38k	$28k	--	$30k	$32k	$29k	$157K	
Stream Stage Monitoring	$8k	$2k	--	$2k	$2k	$2k	$16k	
Coordinate/obtain data from other topic monitoring	$12k	$5k	--	$5k	$6k	$5k	$33k	
Analysis/Reporting	$20k	$15k	--	$17k	$17k	$17k	$86k	
TOTAL	$123k	$76k	--	$81k	$84k	$80k	$444k	

*As proposed, no routine sampling would occur in year 3, although event sampling may occur in this year.

**Cannot predict in which year(s) the event-monitoring costs would be incurred. Funding is only provided to cover one event. No inflation factor was calculated.

***Portion of detailed cross section survey may have possible cost-sharing with post-project monitoring at SEZ and with grant-funded CONCEPTS modeling $$ savings probably in Years 1-3, but uncertain amount).

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Start and End Dates: Summer 2007 through 2012 (5 years), with needs re-assessment

Products and Deliverables: Database of field and data, data analyses and interpretive reports.

Timing of Deliverables: Annually

VII. Water Quality

Water quality monitoring covers several habitats affected by the Angora fire, including stream environment zones, urban areas, ground water and Lake Tahoe. Monitoring for each of these habitats is described below.

A. Stream Ecology and Water Quality

Critical questions addressed are as follows:

- What are trends in sediment and nutrient loads to Angora Creek and the Upper Truckee River corresponding to Angora Fire restoration?

- Has the fire caused violation of state standards for the protection of aquatic life and other beneficial uses listed in the Basin Plan?
- What are post-burn effects on stream hydrology?

Requirements for Water Quality Assessment

Four monitoring stations on Angora Creek: The first site is at upper boundary of residential area, after confluence of main forks, but upstream of the existing Angora SEZ Restoration Project. This site represents all non-urban flow through Angora Creek above the residential area. Second site is downstream of the residential and the Angora SEZ Restoration Project areas. Third site would be on Sawmill Creek above the confluence with Angora Creek. This area receives runoff from the high gradient area of burned forest and residential area in the north burn area, and had been extensively treated for fuels reduction prior to the fire. The fourth site is near the confluence of Angora Creek and the Upper Truckee River. This will provide measurements total loading from the Angora burn area, and will provide information on the effectiveness of treatment through meadows in Washoe Meadow State Park.

Two monitoring stations on Upper Truckee River: These are two existing LTIMP long-term monitoring sites: 1) Near Meyers Station (USGS #103366095) is upstream of Angora Creek and represents Truckee River water quality outside of the burn area. And 2) Upper Truckee at South Lake Tahoe Station (USGS #10336610) is downstream from Angora Creek discharge and represents flow into Lake Tahoe.

Stream monitoring and sampling will consist of Turbidity Threshold Sampling (TTS) with autosampling equipment, which will be calibrated to standard Equal Width Increment (EWI) sampling. Sediment loads are likely to be highly variable in quantity and timing, so these methods are appropriate to best characterize event concentrations and loads.

This sampling design will provide flows, pollutant concentrations and loads for the following critical water quality parameters:

- Nutrients (total and dissolved nitrogen and phosphorus)
- Suspended sediment and fine particles
- Conductivity, including specific anions and cations
- pH, dissolved oxygen, and temperature

It is anticipated that about 80 samples will be collected per site, representing major hydrologic events that transport pollutants to the streams. These include, but are not limited to, summer thunderstorms, fall rainstorms, winter runoff and rain-on-snow events, spring snowmelt events, and summer baseflow. Previous statistical analyses have demonstrated that this is a suitable number of samples for characterizing runoff concentrations and loads within this type of drainage, and for determining statistical significance.

Existing Resources

A number of water quality studies are currently underway within vicinity of the burn area. These include the Lake Tahoe Interagency Monitoring Program (LTIMP), the Angora SEZ Restoration Project, and California State Parks flow measurements on the lower section of Angora Creek.

LTIMP stations have been previously installed on the Truckee River, as described above for the Near Meyers and South Lake Tahoe stations. Currently these stations are used to measure continuous flow, nutrient and sediment concentrations about 30 times per year. (Note, however, that the Near Meyers Station is scheduled for decommission on September 30, 2007, due to funding shortfalls.). The Angora SEZ Restoration historically included two streams sites that were previously monitored, but these sites are non-functional and will need to be restored with new equipment to meet the monitoring needs of this program.

Cost Estimate

With the installation, operation and maintenance of four new sites on Angora Creek, one recommissioned USGS LTIMP site (Near Meyers), and upgrading the equipment at both the USGS LTIMP sites for TTS measurements and increased sample collection, the estimated costs are as follows.

Task	Site Cost	Task Cost
Site Development, Equipment and Instrumentation	$35,000	$140,000
Upgrade Existing LTIMP sites	$20,000	$40,000
Site Maintenance and Sampling	$37,500	$150,000
Analytic and QA/QC	$24,000	$96,000
Supplement Existing LTIMP Analytic Costs	$15,000	$30,000
Data Management and Analysis	$15,000	$60,000
	First Year Total Cost	$516,000
	Subsequent Year Total Cost	$376,000

The total cost for first year implementation, sampling and analysis is estimated at $516,000. Subsequent annual costs without additional installations is estimated at $376,000.

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Start and End Dates: Summer 2007 through 2012 (5 years), with needs re-assessment

Products and Deliverables: Database of field and laboratory data, data analyses and interpretive reports.

Timing of Deliverables: Annually

B. Water Quality of Urban Runoff

It is known that residential areas contribute a large percentage of the total pollutant loading into Lake Tahoe. To what extent will BMPs located within the burned Angora urban area reduce pollutant loads into Angora Creek (and ultimately Lake Tahoe)?

What are the spatial and temporal patterns of runoff volumes generated from burned areas in the urbanized zone of the Angora drainage? Do these runoff volumes create downstream erosion problems?

Are runoff volumes generated from the urbanized areas reduced by restoration and mitigation?

How much nutrient and sediment loading is contributed to Angora Creek from burned areas within the urbanized zone? What is the significance of these loads relative to contributions from the non-urbanized zones?

Requirements for Water Quality Assessment

Four autosampling sites will be established within the urbanized area burned by the Angora fire. These will be deployed within urban conveyance channels that ultimately drain into Angora Creek, at sites that will be chosen to provide estimates of urban runoff volumes, nutrient and sediment concentrations, and pollutant loads. These will be coordinated with the urban upland soils monitoring sites, in order to provide linkage between urban soil monitoring and the Angora Creek monitoring.

Monitoring installations will consist of flumes, stage sensors, autosamplers and turbidity sensors. These data will be directly comparable to the information collected by the stream monitoring stations, and will provide an estimate of the urban runoff contributions to Angora Creek between the Upper Angora Creek and Middle Angora Creek monitoring stations.

At least one continuous recording precipitation gauge will be installed within the project area to record rainfall and snowfall amounts at a consistent interval of 15 minutes or less. This will be installed as part of a network of precipitation gauges installed within the Angora drainage to provide high resolution data throughout the year for both snow and rain events. It is anticipated that at least three of these gauges will be required, one at high elevation on the Angora ridge, a second within the middle of the drainage and the third near the confluence with the Upper Truckee River.

Reconnaissance flow monitoring and grab sampling will be implemented during the first year to determine areas of particular concern for high runoff volumes and loads. Samples will be analyzed for turbidity and suspended sediment and particle size. These results will be documented in GIS maps for coordination with BMP restoration efforts and with the soils evaluation plots.

This sampling design will provide flows, pollutant concentrations and load estimates for the following critical water quality parameters:

- Nutrients (total and dissolved nitrogen and phosphorus)
- Suspended sediment and fine particles
- Conductivity and pH

It is anticipated that about 30 samples will be collected per site, representing major hydrologic events that transport pollutants in urban drainages. These include summer thunderstorms, fall rainstorms, winter runoff and rain-on-snow events, and spring snowmelt. Samples will be collected on a constant flow volume interval and composite to represent event mean concentrations.

Existing Resources

There are a few legacy urban runoff monitoring sites within and peripheral to the Angora burn area that remain available for implementation. Although the monitoring equipment had been removed previously, these represent sites where historical data is available for comparison to the post-fire runoff data.

Cost Estimate

With the installation, operation and maintenance of four new sites in the Angora urban drainage, reconnaissance sampling and three precipitation gages, the estimated costs are as follows.

Task	Site Cost	Task Cost
Site Development, Equipment and Instrumentation	$20,000	$80,000
Site Maintenance and Sampling	$37,500	$150,000
Site Analytic and QA/QC	$12,000	$48,000
Urban Reconnaissance Monitoring, Sampling and Analysis	NA	$30,000
Installation and Maintenance of Precipitation Gauges	$15,000	$45,000
Data Management and Analysis	$15,000	$60,000
	First Year Total Cost	$413,000
	Subsequent Year Total Cost	$333,000

The total cost for first year implementation, sampling and analysis is estimated at $413,000. Subsequent annual costs without additional installations is estimated at $333,000.

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Start and End Dates: Summer 2007 through 2012 (5 years), with needs re-assessment

Products and Deliverables: Database of field and laboratory data, data analyses and interpretive reports.

Timing of Deliverables: Annually

C. Groundwater in the Angora Monitoring Program

Shallow groundwater provides an important linkage between surface water in small streams, and both the lake and deeper groundwater. Shallow groundwater emerges in the Washoe Meadows where permeable glacial till and colluvium contacts a Pleistocene lacustrine deposit. Dissolved material released by the fire may contribute to nutrients and other dissolved materials that may ultimately reach the Lake, the deeper groundwater, the Upper Truckee River, or the wetlands and meadows near the burned area.

Questions:

1. What is the direction and rate of movement of groundwater in the Angora watershed?
2. What are the important shallow groundwater aquifers?
3. How does groundwater link the upper watershed to the Upper Truckee River and the Lake?
4. How has groundwater quality been modified by the fire?

Assessment of groundwater quality and hydrology:

In order to answer the questions about groundwater in the Angora watershed, we will need to:

1. Monitor water levels in existing shallow wells, and sample them for water quality constituents. A total of 10-15 wells will be selected from among about 66 existing wells (at depths of 6-20 ft) in burned area. Quarterly, the wells will be visited, and the water level data be downloaded, and the wells cleared with a bailer. The wells will be revisited within 24 hrs and samples collected for chemical analysis.

2. Install 10 piezometers near intermittent stream courses to measure groundwater recharge.
3. Install continuous water level recorders (Global Water WL-15) will in the selected wells and installed piezometers.
4. Quarterly, visit the wells, downloaded the water level data, and clear the wells with a bailer. The wells will be revisited within 24 hrs and samples collected for chemical analysis.
5. Analyze the well samples for dissolved constituents, including nitrate-N, ammonium-N, soluble reactive phosphorus, total dissolved phosphorus, and conductivity.
6. Plot the water level data on a topographic map for each season, and draw contours of water table elevations.
7. Plot chemistry data to identify areas of elevated concentration of nutrients and dissolved solids.

Cost summary:

1. Review existing information on groundwater conditions and monitoring wells: $4,000
2. Install piezometers: $2,000
3. Install water level recorders: $6,000
4. Service wells 4x/yr: $3,000
5. Analyze samples: $10,000
6. Data analysis, interpretation and reporting: $15,000

First year total cost: $40,000

Subsequent year annual costs: $28,000

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Start and End Dates: Summer 2007 through 2012 (5 years), with needs re-assessment

Products and Deliverables: Database of field and laboratory data, data analyses and interpretive reports.

Timing of Deliverables: Annually

D. Lake Water Quality

Lake Tahoe will be the ultimate recipient of material that may wash off the burn area and into Angora Creek and the Upper Truckee River. The decline of water clarity in Lake Tahoe has been well documented since 1968 (UC Davis) and it is known that fine sediments and nutrients have been the cause of this decline. To the extent that these materials drain off the burn site and enter the Lake, the clarity could be further reduced following the Angora Fire.

The questions of concern associated with Lake water quality include:

1. What are the short-term and long-term affects of pollutants washed in from the burn area on lake-wide clarity and water quality?

2. Are there localized affects on nearshore water quality along the South Shore and especially in the immediate vicinity of the mouth of the Upper Truckee River?

3. What are the affects on shallow-water aquatic plant communities and attached algae along the South Shore?

Currently, UC Davis operates a comprehensive Lake water quality/biology monitoring program as part of the Lake Tahoe Interagency Monitoring Program. Samples for physical, chemical and biological parameters are sampled at two, deep-water stations in the northern one-third of the Lake. In general it is thought that Lake Tahoe is a relatively well-mixed system from north-south and east-west. Indeed, current water quality management decisions (e.g. TMDL lake response, Thresholds attainment) are based on the existing LTIMP Lake stations. However, there will likely be localized water quality affects in the Lake in the vicinity of the Upper Truckee River during periods of significant hydrologic input associated with summer thunderstorms, fall rains, rain-on-snow events and spring snowmelt. UC Davis also currently monitoring attached algae around the Lake as part of LTIMP. Previously, the Desert Research Institute conducted continuous turbidity and nearshore suspended algae (phytoplankton) around the Lake with emphasis on the South Shore; however, this was a limited program that ended in 2004.

The current Lake sampling program is sufficient to allow us to answer question #1 (i.e. affects on lake-wide clarity and water quality). Additional sampling along the South Shore will be needed to address question #2 (nearshore water quality). A survey of approximately 20 sites in the southern portion of Lake Tahoe will be monitored for clarity (Secchi disk), algal biomass, nutrient concentrations, temperature and light transmission in a vertical profile. This sampling will be done five times per year in association with significant hydrologic events.

Question #3 will partially funded as part of the LTIMP attached algae monitoring program; however, additional sites will be required and new surveys for aquatic plant growth will be done. These surveys will be primarily along the South Shore and done four times per year.

Cost Summary:

The anticipated additional costs include:

South Shore, near shore water quality surveys ($30,000/yr.)

Attached algae and aquatic plant surveys ($10,000/yr.)

Total: $40,000/yr.

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Start and End Dates: Summer 2007 through 2012 (5 years), with needs re-assessment

Products and Deliverables: Database of field and laboratory data, data analyses and interpretive reports.

Timing of Deliverables: Annually

VIII. Biological Resources

The purpose of this monitoring plan is to understand the extent to which key indicators of biological resource condition have been affected by the Angora fire and to track the effectiveness of rehabilitation efforts to restore biological resources.

Assumptions

- The BAER Team (and other Forest Service efforts) will provide a thorough yet coarse assessment and inventory of biological resource impacts. For example, it is assumed that acreage of different habitat types burned by severity class will be estimated and reported.
- We are tasked with identifying a monitoring plan/strategy that is designed to answer "effectiveness" and "status and change" type monitoring questions.
- "Implementation/compliance" and "validation" type questions will be reserved for another venue.
- To the extent practical and appropriate, biological resources sampling efforts will be co-located with other topic-area monitoring efforts of interests. For example, at any given sample site, we think it most cost effective and informative to also collect parameters related to soil, geomorphology, air, water quality, and vegetation.
- This monitoring plan has been developed based on a preliminary understanding of the burned area. Although individuals on the team were familiar with the area prior to the burn, nobody has visited the areas since

the burn. Consequently, adjustment to the sampling design and associated costs should be expected as the team gains a better appreciation of potential impacts to biological resources across the area.

Monitoring Questions

In general, we are interested in monitoring and evaluating the status of biological resources at the burned area and comparing that with reference conditions over time. This can be accomplished by either assessing conditions adjacent to the burned area or by sampling an analogue (nearby) watershed with similar characteristics or both. Sampling adjacent areas (buffered burned area) may be confounded by emigration of biological resources from the burned area. However, some insight can be gained by understanding the extent to which adjacent areas have also been affected be the fire. Thus, the design proposed will be a combination of both in order to maximize our understanding of how the fire has affected biological resources.

We propose to use the following framework/outline in order to organize monitoring questions and best understand the response of natural resources:

Aquatic, Meadow, and Riparian Ecosystems

- Streams (with particular emphasis on Angora Creek)
- Small Lake (>20 acres)
- Wetlands (includes ponds)
- Lake Tahoe

Terrestrial/Upland Ecosystems

- Urban intermix – patches of open space found within a subdivision
- Wildland Urban Intermix – the area extending ¼ mile from the perimeter of a residential area into the wildland.
- Wildland – area primarily unaffected by residential development with the exception of forest roads and trails.

Special Status Species and Communities

- Animals
    - Northern Goshawk
    - California Spotted Owl
    - Willow Flycatcher
    - Lahontan Cutthroat Trout
    - Bear

- Plants
    - mosses
- Communities
    - Fens
    - Aspen

The table below lists the detailed questions, sampling approach, and sampling costs.

Existing Information that may inform this effort:

- Lake Tahoe Urban Biodiversity Project (MSIM)
- Multi-species Inventory and monitoring Project (MSIM)
- Forest Inventory and Analysis (FIA)
- IKONOS Vegetation Layer
- USFS RSL-EVEG Layer
- NRCS new Soil Survey layer
- Angora Creek and Upper Truckee River Bioassessment (Dave Herbst, SNARL)
- BAER Report
- Fuel Treatment/Prescription Layer

Biological Resources: Summary of methods, indicators, and costs

Ecosystem Component	Question(s)	Primary Indicator(s)	Protocol/Method	Number Samples/visits per year	Cost/Sample or Reach	Total Cost/Year
Aquatic, Meadow, and Riparian Ecosystems						
Streams (Angora Creek and Surrogate)	What is the current biological condition of Angora Creek in comparison to a surrogate stream and how is biological condition responding to restoration efforts.	B-IBI and RIVPACS-O/E	California SWAMP Bioassessment Protocol	3 reaches (plus 3 reaches on surrogate stream)	$3,000	$18,000
Streams	How are fish populations responding to rehabilitation effort on Angora Creek?	Fish Sampling	Electro Fishing	3 reaches	$6000	$18,000
Streams	What is the current biological condition of Angora Creek riparian habitat in comparison to a surrogate stream and how is biological condition responding to restoration efforts.	Species Richness, Focal Species occurrence	Standardized Bird Point Count Methods	10 samples	$1,000	$10,000
Streams	Have invasive species been introduced into Angora Creek?	Invasive species occurrence and abundance	Line Transect and area search	Stream Corridor	$5,000	$5,000
Small Lakes	Have invasive species been introduced in small lakes used by fire suppression operations	Invasive species occurrence and abundance	Line Transect and area search	3 small lakes and associate perimeter	$7,000	$21,000
Wetlands, Meadows and Ponds	What is the current biological condition of wetlands, meadows and ponds in the Angora Creek watershed in comparison to a surrogate stream and how is biological condition responding to restoration efforts.	Bird Species Richness, Focal Species occurrence, Plant vigor and richness	Standardized Bird Point Count Methods, Line Transect and area search	3 reaches (plus 3 sites in surrogate watershed)	$7,000	$21,000

Terrestrial/Upland Ecosystems						
Urban intermix, WUI, Wildland	How will wildlife populations and forest vegetation respond to natural succession and revegetation efforts?	Bird Species Richness, Focal Species occurrence, Vegetation - structure vigor and composition	Standardized Bird Point Count Methods, camera stations, small mammal trapping, FIA – post-fire protocol.	30 samples	$10,000	$300,000
Special Status Species (SSS) and Communities						
Animals	What is the current status of SSS animals in the area and how are they responding to restoration actions?	Species occurrence and reproductive activity	Standardized Survey Protocols	6 species	$4,000	$24,000
Plants	What is the current status of SSS plants in the area and how are they responding to restoration actions?	Species occurrence	Standardized Survey Protocols	4 species	$2,000	$8,000
Communities	What is the current status of SSS communities in the area and how are they responding to restoration actions?	Community composition and vigor	Standardized Survey Protocols	2 communities	$5,000	$10,000
Total Costs: First Year						**$435,000**
Total Costs: subsequent years						**$392,000**